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Original communication

Stability of lip-print patterns: A longitudinal study of Saudi females

Magda A. Eldomiaty, M.D, Professor of Anatomy and Embryology [a,b,*],
Rasha I. Anwar, M.D, Assistant Professor of Anatomy and Embryology [a,c],
Sami A. Algaidi, PhD, Associate Professor of Anatomy and Embryology [a]

[a] Department of Anatomy, College of Medicine, Taibah University, Saudi Arabia
[b] Department of Anatomy, College of Medicine, Tanta University, Egypt
[c] Department of Anatomy, College of Medicine, Assiut University, Egypt

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ABSTRACT

Lip-print groove patterns have recently been verified as a unique parameter for identification. This study investigated the stability of lip-print patterns over time to validate their secure use in civil and criminal investigations. One hundred and sixteen female lip prints were analyzed and compared with the prints of the same subjects taken 3 years earlier. The old and new lower lip prints of each subject were examined for similarities in the groove patterns in different areas of the lip (lower right, lower middle and lower left), and a score for similarity was developed for the statistical analysis of the lower lip stability data. No significant difference in the frequency of pattern types was detected between old and new prints ($P > 0.05$). Statistically, 89.6% of subjects showed characteristic typical groove(s) in the lip area(s) of the old and corresponding new prints: 24.1% in the three areas, 48.3% in two areas and 17.2% in one area. This study proves the lasting stability of lip-print patterns over the years in Saudi females and recommends paying attention to the presence of characteristic typical grooves in these prints. Further studies on larger samples, including male prints, should be performed to validate the lip prints for criminal use.

1. Introduction

The lip prints are the normal lines and fissures in the zone of transition within the human lips between the labial mucosa and the outer skin. They are identifiable as early as the sixth week of intrauterine life, and from that time on, their pattern rarely changes, resisting many afflictions, including herpetic lesions.[1,2]

There are few studies that have investigated lip prints, in spite of their possible prominent use as evidence in genetic studies[3] and forensic medicine.[4] In the last few years, lip prints have been proven to be unique and distinguishable for every individual, similar to fingerprints. The analysis of the lip prints left at the scene of a crime (on cups, cigarette butts or the skin) and their comparison with those of a suspected person constitutes an important tool for identification and is often considered the key in solving a crime.[5–7] Genetic studies have proven that specific patterns on the lower lip are associated with non-syndromic cleft lip, with or without a cleft palate.[3]

Handling out of lip prints depends first on observation and photographing that should be made prior to any processing in order to protect the evidence. In some circumstances, lip prints can be covered with substances like aluminium powder or silver metallic powder to allow direct observation and photography and if lipstick is present, the lipstick itself should be analyzed in order to determine its constitution.[5]

The individuality of lip prints has been proven in many populations, such as the Chennai, Japanese, Egyptians and Saudi.[8,9]

Additionally, a cadaveric study proved that, even after fixation, a satisfactory identification rate could be achieved from the examination of the lip prints.[4] Further, it was proven that the lip print patterns are not identical in monozygotic twins or in different individuals in the same family, confirming that there is no hereditary pattern of lip prints.[9]

Lip print-analysis (chieloscopy) is a complex process that is not restricted to studying visible prints but also the latent ones. Few classifications have been described for the types of groove that make up the lip print pattern,[10,11] and to date, most recent studies continue to use modifications of these classifications consistent with gender and location.[9,12]

* Corresponding author. College of Medicine, Taibah University, Aljameaat Street, Postal Box: 30001, Almadinah Almonawarrah 41411, Saudi Arabia. Tel.: +966 48223083, +966 559579980 (mobile).
E-mail addresses: drmagda10@gmail.com (M.A. Eldomiaty), ribrahem_2000@yahoo.com (R.I. Anwar), algaidi@hotmail.com (S.A. Algaidi).

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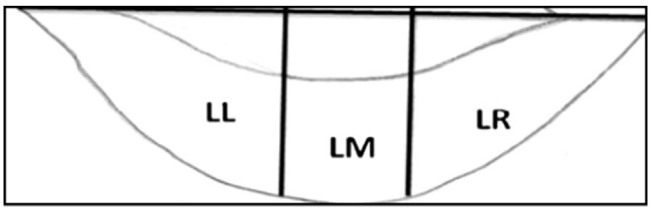

Fig. 1. A diagram showing the topographic areas of the lower lip. LR, lower right; LM, lower middle; LL, lower left.[9]

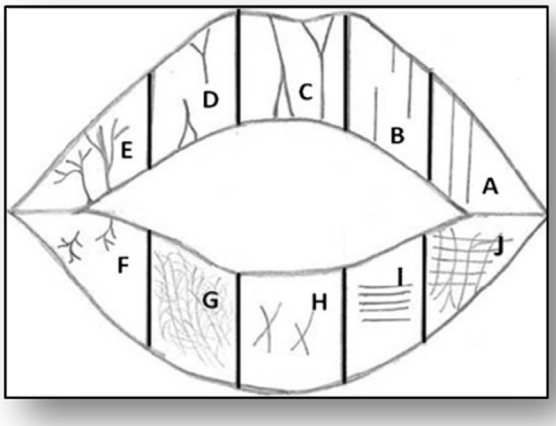

Fig. 2. A diagram showing the lip-groove types, as follows: A = complete vertical; B = incomplete vertical; C = complete bifurcated; D = incomplete bifurcated; E = complete branched; F = incomplete branched; G = reticular pattern; H = X or comma form; I = horizontal; J = horizontal with other forms (vertical, bifurcate or branching).[9]

Although it has been shown that peeling off of the superficial layers of the skin due to the environmental changes does not mask the pattern of the lip print,[9] the permanence and stability over time of lip prints remain a subject of controversy. Aiming to make it safe to assume that cheiloscopy is a novel and precise mean for genetic and criminal identification, the present study analyzed the lip-prints' patterns characteristics and investigated their stability over the years, comparing new prints taken from the subjects with their old prints taken 3 years earlier.

2. Materials and methods

A total of 116 Saudi females were included in the study. All of the subjects were chosen from the student population of Taibah University in the Almadinah Almonawarrah province, and their ages ranged from 16 to 22 years. A written informed consent was obtained from each subject, and the study protocol was in agreement with all Saudi Arabia University ethical standards.

The study was limited to the lower lip, which was divided into three areas: the lower right, lower middle and lower left (Fig. 1). Lips that showed any inflammation, cicatrisation or deformity were excluded from the study.

The prints were taken following Youssef and El. Emary,[13] and Domiaty et al.[9]: a thin film of lipstick (Red or brown, non-persistent, non-glossy, non-metallic Lise Watier or Black Up) was applied onto cleaned and dried lower lips and left for 3 minutes, and then the impressions of the lips were taken on white papers (white A4 ROCO Premium 80-g copy papers) by rolling the paper (with applying slight, gentle pressure) onto the relaxed lips, obtaining the print from one angle of the mouth to the other. Eight prints were taken from each individual to select a clear print suitable for pattern analysis.

Data collection was carried out from September, 2009 to October, 2012. The old prints were stored on the papers in envelopes for 3 years until the other lip prints were developed by the same method from the same subjects. All of the prints were examined by magnifying lenses, photographed by a digital camera (Nikon 300 D 12.5 MP) and transferred to the computer to be examined by the Microsoft Office Picture Manager Program.[9] The prints of each individual were included in the same picture to be examined for the similarity of their lip print patterns. Analysis of lip prints was done by two investigators and the inter-observer agreement was one-hundred percent.

The lip prints were studied based on the classification used in Domiaty et al.[9] into 10 types, as follows: A = complete vertical, B = incomplete vertical, C = complete bifurcated, D = incomplete bifurcated, E = complete branched, F = incomplete branched, G = reticular pattern, H = X or comma form, I = horizontal, and J = horizontal with others forms (vertical, bifurcate or branching) (Fig. 2).

For the statistical analysis of the results, a score for similarity was developed as shown in Table 1, and the data were analyzed using SPSS version 13. The data were expressed as numbers and frequencies. The Mann Whitney Test was used to compare the frequency of pattern types and similarity scores in the studied cases, and $P < 0.05$ was considered significant.

3. Results

I) *The percentages of frequency and pattern type in different areas of the old and new lip prints.*

The percentages of frequency and pattern type in different areas of the old and new lip prints are described in Table 2.

In each of the lip print areas, the same groove types were recorded in the old and in the corresponding new prints. The LM area was found to be the best area for the determination of the lip print patterns' similarity, whereas the LL area was the least useful area for this determination.

1. In the lower right area: type C showed the highest and equal frequencies (72.4%) in both the old and new prints, followed by type A (10.3%) in both the old and new groups and finally type H, which constituted the lowest frequency (3.4%) in both groups. Type E (10.3%, 6.9% in the old and new prints, respectively) and G (3.4%, 6.9% in the old and new prints, respectively) were also observed with inter-group differences and lower frequencies. No significant difference was detected between the lip-print patterns of the old and new prints in this area ($P = 0.955$).

Table 1
The score for determining the similarity and consistency of the old and new lip prints' patterns.

Score	0	1	2	3	4
Character	No detected similarity	Same groove type in one or more areas of the lip	Identical groove (s) in one area of the lip	Identical groove (s) in two areas of the lip	Identical groove (s) in the three areas of the lip

Table 2
Frequency and pattern type percentages in different areas of the old and new lip prints.

Area	Groove type	Old print (No = 116)	New print (No = 116)	*P* (in each group)	*P* (between groups)
LR	Complete vertical (A)	12 (10.3%)	12 (10.3%)	0.955	0.905
	Complete bifurcate (C)	84 (72.4%)	84 (72.4%)		
	Complete branched (E)	12 (10.3%)	8 (6.9%)		
	Reticular (G)	4 (3.4%)	8 (6.9%)		
	Criss-crossed (H)	4 (3.4%)	4 (3.4%)		
LM	Complete vertical (A)	40 (34.5%)	40 (34.5%)	1.000	
	Complete bifurcate (C)	60 (51.7%)	60 (51.7%)		
	Complete branched (E)	12 (10.3%)	12 (10.3%)		
	Reticular (G)	4 (3.4%)	4 (3.4%)		
LL	Complete vertical (A)	20 (17.2%)	20 (17.2%)	0.508	
	Incomplete vertical (B)	4 (3.4%)	4 (3.4%)		
	Complete bifurcate (C)	76 (65.5%)	68 (58.6%)		
	Complete branched (E)	12 (10.3%)	12 (10.3%)		
	Reticular (G)	4 (3.4%)	12 (10.3%)		

P = significance for the Mann–Whitney Test at $p < 0.05$.

2. In the lower middle area: all of the recorded groove types showed the same frequency in both the old and new prints. Type C showed the highest frequency (51.7%), followed by type A (34.5%) and type E (10.3%). The lowest frequency was recorded for type G (3.4%). No significant difference was detected between the lip-print patterns in the old and new prints in this area ($P = 1.000$).
3. In the lower left area: type C showed the highest but differing frequencies (65.5% in the old but 58.6% in the new prints), followed by type A (17.2%) in both the old and new groups. Next were type E (10.3%) in both the old and new groups, whereas type H constituted the lowest frequency (3.4%) in both groups. Type G showed lower and different frequencies (3.4% in the old but 10.3% in the new prints). The lowest but equal frequency in both groups was recorded for type B (3.4%). No significant difference was detected between the lip-print patterns in the old and new prints in this area ($P = 0.508$).
4. Interestingly, the difference between the three areas of the lip, as within each area, was also non-significant ($P = 0.905$), which further adds to the stability of the lip-print patterns over time.

II) *The numerical assessment of lip print pattern stability*:

The frequency of the similarity and constancy scores from the old and new lip-print patterns were shown in Table 3. Most of cases (89.6%) showed identical grooves in the old and new prints, with scores of 2, 3 or 4 for similarity/constancy, while none of the specimens showed a score of 0.

1. 24.1% of cases achieved the score 4 (identical groove (s) in the three areas of the old and the corresponding new lip prints) (Fig. 3).
2. 48.3% of cases achieved the score 3 (identical groove (s) in two areas of the old and the corresponding new lip prints) (Fig. 4).

Table 3
Frequency of the similarity/consistency scores of the old and new lip print patterns.

Score	Count (%)
0	0
1	12 (10.4%)
2	20 (17.2%)
3	56 (48.3%)
4	28 (24.1%)

3. 17.2% of cases achieved the score 2 (identical groove (s) in one area of the lip) (Fig. 5).
4. 10.4% of cases achieved the score 1 (same groove type in one or more areas of the lip) (Fig. 6).
5. None of the cases achieved the score 0 (no detected similarity).

4. Discussion

In the last few years, many studies have analyzed the morphological patterns of lip prints and revealed their uniqueness and possibilities for personal identification.[14–16] However, to ensure their utility in criminal identification, the stability of lip-print patterns over time should be confirmed, similarly to fingerprints, which have become an important biometric technique for personal identification after their stability was confirmed throughout life.[17]

In this study, the permanence of lip-print patterns over time was investigated by analyzing and comparing the lip prints of the same subjects before and after a 3 year period. This trial was designed to prove the consistency of the patterns' details over a long duration of time to exclude the fluctuating responses of the weather and/or individual habits, as was advised by Coward[18] and Domiaty.[19]

The study relied on studying areas of the lower lips using a method similar to that of Verghese et al.,[20] who prefer the lower lip for studying lip print patterns as this is the most frequently found part at a crime scene. Additionally, the study attempted to determine the stability of the patterns' details, not only the patterns' types, as were described by El Domiaty et al.[9] These authors showed that although the same subject could develop different shapes of lip prints, the specificity of the groove patterns at the same site of the lip can be observed.

The present study reveals that, in each of the lip print areas, the same groove types were recorded in the old and new prints with equal or differing percentages. The LM area is the best area for the determination of similarities in the lip print pattern, while the LL area is the least suitable area for its determination. Most importantly, the numerical assessment of lip print pattern stability reveals that most of cases (89.6%) show identical grooves in the old and new prints.

Until now, there has been no documented research on the stability of the lip-print pattern over time. However, Coward[18] studied the stability of many features that appeared on a lip print and might be relevant to individualization. He explored the size and shape of the lips to understand whether they could represent a good basis for initial comparison, noting that the contact line and notches

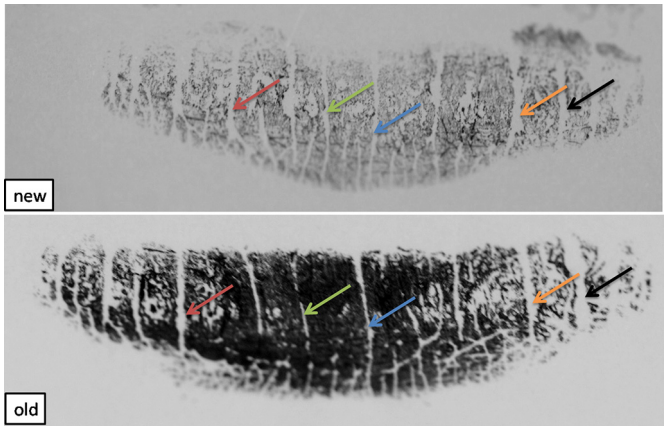

Fig. 3. A photograph of the new and old lower lip prints of the same subject showing identical grooves in the three areas of both prints (score 4).

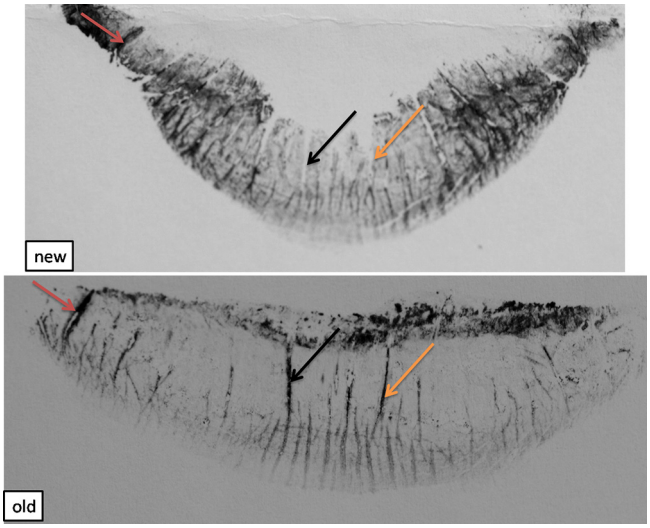

Fig. 4. A photograph of the new and old lower lip prints of the same subject showing identical grooves in the lower left and middle areas of both prints (score 3).

showed a high degree of consistency. He reported that the philtrum could be of major use for the orientation of the lip print and attempted to obtain a profile of the subject; however, he was not very accurate in demonstrating the actual soft tissue profile. He also recorded that the facial hairs that came into view on the contact prints represented a highly repetitive detection rate for women (90%), but not for men (31%).

Our study considered the pattern types and numerical scores for identical grooves in old and new prints to determine lip print stability over time. Most of our cases (89.6%) showed typical or identical groove(s) in one or more areas of the old and new prints, whereas the rest (10.4%) showed similar patterns in one or more areas. These data can help us to explore the importance of groove specificity in identifying individuals, as was proven by Domiaty et al.[9] Recently and in accordance with our results, Ludwig and Page[21] compared Lip print impressions with known and unknown individuals as well as photographs, and demonstrated that it was

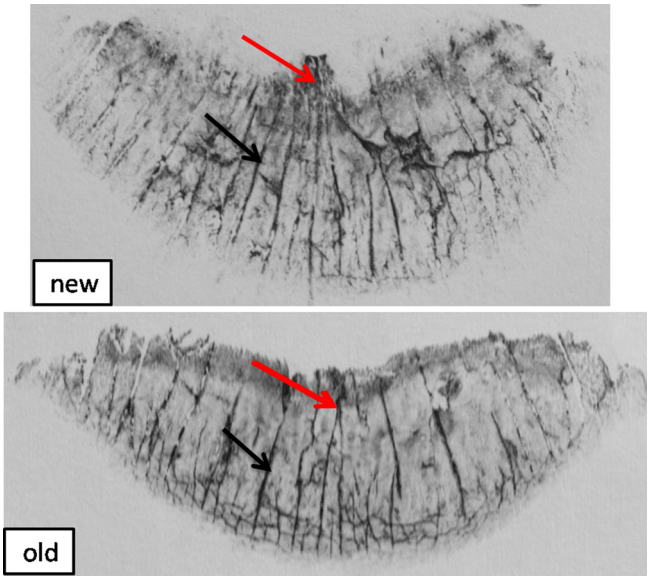

Fig. 5. A photograph of the new and old lower lip prints of the same subject showing identical grooves in lower middle area of both prints (score 2).

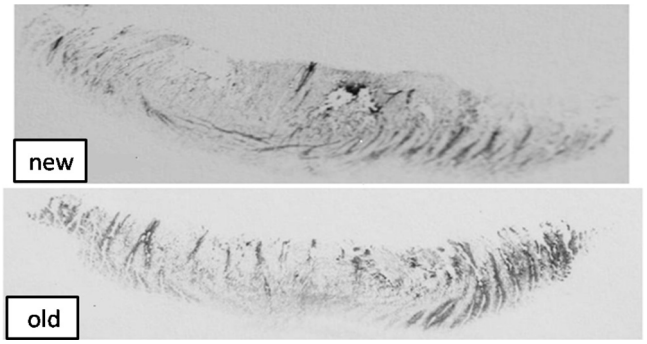

Fig. 6. A photograph of the new and old lower lip prints of the same subject showing the complete bifurcated pattern of lip print in the three areas of both prints (score 1), although shedding of the skin in the middle area of the new print can be seen.

possible to establish whether an impression could be linked to the source determining the importance of pattern typing and cataloguing of the lip prints to include pattern imperfections. On the other hand, Coward[18] suggested that the pattern classifications were of limited use in distinguishing or identifying individuals, claiming that the pattern classification could only assist in searching through large databases that do not yet exist. This suggestion of Coward could be due to his use of a simplified classification for pattern types (linear, reticular and mixed) and the lack of consideration of identical grooves in old and new prints. Despite this contradiction, Coward[18] proved that almost 80% of the tested cases were consistent after 7 months. Importantly, he also attributed the non-constancy of the pattern type in the rest of cases to operator error in classification and/or the blurring effects of lipstick.

That the LM area achieved the highest level of similarity between lip-print patterns in the old and new prints might be due to the ability of the operator's hand to stabilize the pressure in this area over the lateral areas. Additionally, that the lower right area shows a higher rate of similarity than the left area could be the result of differences in the pressure applied to the lip area while taking the prints, as the operator was right-handed and was always standing on the right side of the subject. In this way, he would begin to roll the paper from the right angle of the mouth directly toward the left, and this procedure could require changing the pressure from the hand. This can reflect the utmost importance of developing a standardized method or specified instrument for taking the lip print. Consistent with this, Verghese et al., [20] in a study on lip-print types among the people of the Kerala (India), used the middle 1 cm of the lower lip as the study area. Also in agreement with our opinion that the pressure difference could be the cause of the non-similarity, many recent studies have suggested that, for the complete utilization of lip prints as forensic evidence, a standardized method and/or sophisticated software tools should be developed.[9,22]

5. Conclusions and recommendation

This study revealed that the lip-print pattern is stable over time and can be used as a morphological aid in genetic and forensic investigations.

The study explored the importance of studying the specific identical grooves appearing on the lip print, in addition to the morphological patterns as a whole.

More studies should be performed using larger numbers of individuals from both sexes to confirm the rate of stable lip-print patterns and to investigate the gender-based differences, thereby validating the lip print as a powerful forensic tool in criminology.

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Ethical approval
None.

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